IFDM System Description and Example of Operating IFDM System

James E. Ayars
United States Department of Agriculture
Agricultural Research Service
Fresno
jayars@fresno.ars.usda.gov

Lisa M. Basinal
Center for Irrigation Technology
California State University, Fresno
lbasinal@csufresno.edu

Kathleen Buchnoff
Integrated Drainage Management
Agricultural Drainage, Department of Water Resources
Fresno
kbuchnof@water.ca.gov

Vashek Cervinka
Westside Resource Conservation District
Davis
vac@dcn.org

Edward M. Norum
Consultant, Center for Irrigation Technology
California State University, Fresno
edward_norum@csufresno.edu

Chapter 2. IFDM System Description and Example of Operating IFDM System

A. Introduction

In the IFDM system, the most significant component that has regulatory requirement is the solar evaporator. In this chapter, an IFDM system will be described in general terms. The regulatory aspects of an IFDM system are detailed in the Appendix pages A-26 to A-30, A-51 to A-57, A-65 to A-97 of this manual, as well as in the Landowner's Manual.

B. Basic Description of IFDM System

An IFDM system is an on-farm water and salt management system, using saline drainage water for irrigation as a means to manage salinity and to dispose of saline drainage water. There is no set configuration or design of an IFDM system. The following component description is based on the experimental IFDM system currently in use at Red Rock Ranch (RRR) and is only presented here to highlight potential considerations for the design of an IFDM system. The RRR system includes a border strip of trees to intercept regional groundwater flow, crop production areas for salt-sensitive crops, salt-tolerant crops and halophytes and a solar evaporator. Each of the production areas has a subsurface tile system that drains to a sump, sump pumps and piping to move the collected subsurface drainage water to each of the cropping areas or to the salt harvest area.

In the first production area, irrigation or surface (tailwater) water is used to irrigate salt-sensitive crops. This generally will be the largest production area in a system. The subsurface drainage water from the salt-sensitive area is collected and may be blended with fresh water or tailwater for use on the next production area, which is cropped with salt-tolerant plants. Drainage water from this production area is collected and used to irrigate salt-tolerant crops, such as forage grasses and halophytes. Drainage water from the halophyte production area is discharged to the solar evaporator (salt harvest area) for final disposal, leaving dry salt as a product, which may be disposed of, marketed or stored.

Since all of the production areas will have subsurface drainage and pumping systems installed, there is no requirement to maintain a fixed position for each of the aforementioned production areas. It may be possible to move these areas around within the system. This will depend on the salinity status in the soil profile and the groundwater quality. This would entail developing practices such as the cyclic use of saline and good quality water as proposed by Rhoades (1989).

1) Border Strips of Trees

The rows of trees used to intercept regional flow should be located up-gradient of the area where the IFDM system is being constructed. There is potential to use large quantities of water with trees having deep extensive root systems. Trees also are useful along crop areas where shallow groundwater problems arise. Eucalyptus, Athel and Casuarina trees are selected for their ability to use large volumes of water and are frost- and salt-tolerant (survive with water with TDS of 8,000-10,000 ppm). Trees also are useful as windbreaks and in the control of spray drift.

2) Crop Production Areas

IFDM systems have been designed with up to three distinct production areas and a solar evaporator. The number of production areas used in the final design will be determined by the quality and quantity of the drainage water and the proposed cropping plan.

The purpose of crop areas is to:

- Maximize economic production.
- Use drainage water as a resource to produce crops, while saving energy and water.

As the IFDM system design and operation has evolved, there has been a customizing of the terminology to better describe the various steps in the process. Early work referred to the reuse areas as stages, but the term production areas, in relation to the quality of water being used and the number of reuses of drainage water, will be used in this manual.

The first production area of the IFDM system is irrigated with good quality water and supports production of salt-sensitive crops. The subsurface drainage system provides the drainage necessary for salt management and the collected drainage water is used for irrigation in the next production area. Surface drainage (tailwater) in this area should be captured and used for irrigation on other areas requiring good quality low-salinity water. Generally, the best fields with the least salinity problems will be selected for inclusion in the first production area. If needed, some leaching will be done to enable production of salt-sensitive crops. Crop examples in the first production area may include a rotation of salt-sensitive crops i.e., vegetables and alfalfa.

The second production area of the IFDM system is the first step in drainage water volume reduction and is the first reuse area. Crops with a higher salt tolerance are irrigated with subsurface drainage water collected from the salt-sensitive crops. Crop examples in the first reuse area include cotton and forage grasses of moderate-to-high salt tolerance. If the salinity of the drainage water is too high for cotton and similar crops, some blending can be done to match crop salt tolerance and EC of the irrigation water. The area used in production of salt-tolerant crops will be determined by the volume of drainage water collected from the first production areas. The use of water with higher salinity levels will require additional deep percolation (leaching requirement) to maintain the salt levels in the soil profile, which will require careful design of the drainage system. Surface runoff can be recycled to the same field through a tailwater return system or on to the next reuse area. Runoff from the reuse area should be minimized.

The production area of the IFDM system that contains the most salt-tolerant forage crops is irrigated with the subsurface drainage water collected from the first reuse. Crops in this area tend to be more salt-tolerant than most agronomic crops and may result in a limited economic value for this area, which suggests that this production area should be minimized. Deep percolation losses also will increase with higher salinity levels in the irrigation water, which will have to be considered in the drainage design. Halophytes can be grown and this area is a disposal site for the last possible reduction of drainage water volume. Most of the halophytes currently have little economic value. Again, surface runoff should be minimized.

At each step in the process, the goal is to reduce the total volume of water being collected under each production area so the minimum amount of water is collected and ultimately discharged to the solar evaporator. It should be noted that there is no mention of the concentration of salt in the drainage water collected under each production area as would be expected in a purely theoretical calculation. This is because in the San Joaquin Valley the total mass of salt in the soil profile below the root zone masks any concentrating effect that may occur as a result of crop water use. By the time the deep percolation has moved to the drainage system, the deep percolation has mixed with the shallow groundwater and reflects the groundwater salinity. This means that in the San Joaquin Valley there is probably not a need for growing halophytes. It may be possible to confine the production to the salt-sensitive crops and moderately salt-tolerant crops with the disposal being accomplished by successive reuse on the salt-tolerant crops and finally discharge to a solar evaporator. This is a potential that should be evaluated during the design.

3) Solar Evaporator (Salt Harvest Area)

The Salt Harvest Area is the final treatment point of saline drainage water in the IFDM system. As a result of the evaporation that occurs in the solar evaporator, a dry salt product will be produced.

Solar Evaporator Regulations under Title 27 define solar evaporator, water catchment and standing water. The salt harvest area consists of a solar evaporator or solar evaporator and water catchment basin. "Solar evaporator" means an on-farm area of land and its associated equipment that meets all of the following conditions:

1. It is designed and operated to manage agricultural drainage water discharged from the IFDM system.
2. The area of the land that makes up the solar evaporator is equal to, or less than, two percent of the area of the land that is managed as the IFDM system.
3. Agricultural drainage water from the IFDM system is discharged to the solar evaporator by timed sprinklers or other equipment that allows the discharge rate to be set and adjusted as necessary to avoid standing water within the solar evaporator or, if a water catchment basin is part of the solar evaporator, within that portion of the solar evaporator that is outside the basin.
4. The combination of the rate of discharge of agricultural drainage water to the solar evaporator and

subsurface tile drainage under the solar evaporator provides adequate assurance that constituents in the agricultural drainage water will not migrate from the solar evaporator into the vadose zone or waters of the state in concentrations that pollute or threaten to pollute the waters of the state.

The operation and management regulations are covered in Title 27 and the designer must fully comply with this statute. Additionally, there are several water quality acts and regulatory considerations that are included in the design and operation. All the pertinent regulations and environmental acts are provided in the Appendix.

C. Example IFDM System – AndrewsAg Inc. (previously Rainbow Ranch) IFDM project

1) Background Information

AndrewsAg Inc. is a diversified farming operation that grows, packs and ships vegetable crops and grows cotton in the southern San Joaquin Valley.

Prior to 1999, their only option for in-region disposal of subsurface drainage water from 1,034 acres was through the use of 100 acres of evaporation ponds. The operation, maintenance and monitoring costs associated with these ponds were too high to be economically viable. In addition to these costs, AndrewsAg was required to establish and maintain a 125-acre pond, for compensation habitat. These economic factors forced them to consider other management strategies for drainage disposal while maintaining agricultural productivity and meeting environmental requirements. Two possible alternative choices were either to retire the farmland or develop an IFDM system on this farm. The IFDM system was the preferred choice.

The transition to the IFDM system started in 1999. Project objectives included: (1) closing the evaporation pond; (2) managing drainage water, salt and selenium on the farm with regard to environmental requirements; (3) using drainage water for the commercial production of salt-tolerant crops, grasses and halophytes; (4) sustaining agriculture and the production of high value salt-sensitive crops; and (5) converting the operation of the evaporation pond into a solar evaporator.

2) Initial IFDM System Design

Subsurface drainage systems had been installed in the cropped area (1,034 acres) prior to 1999. After consultation with Michael Andrews, owner of AndrewsAg, the IFDM system was designed as follows:

- salt-sensitive crops on 752 acres
- salt-tolerant crops on 242 acres
- halophytes on 40 acres of drained crop area.
- The cells 2A & 2B (20 acres) of the existing evaporation pond were reserved for a solar evaporator.

The schematic of the system is given in Figure 2-1.

Additional sumps, pumps and pipes were installed at strategic parts on the property for the management of the reused drainage water. A larger area of both halophytes and solar evaporator was chosen to provide for the future expansion of the IFDM system.

The development of the IFDM system proceeded using these steps:

1. Discontinued discharge of drainage water into evaporation ponds to dry the cells.
2. Created a temporary 10-acre solar evaporator for discharging drainage water before installing a permanent solar evaporator.
3. Planted halophytes in the 40-acre northern area of fields.
4. Installed two new sumps for reuse of drainage water.
5. Established a permanent solar evaporator.
6. Transferred salt from the remaining cells of the evaporation pond into the new solar evaporator.

Initially, the IFDM system included this cropping system:

Salt-sensitive crops	752 acres	72.7 %
Salt-tolerant crops	242	23.4
Halophytes	40	3.9
Total	1034	100.0

It is important to note that much of the surrounding land is fallow, and there is little-to-no influence of subsurface regional flow at this farm.

3) Description of Current IFDM System

Over the last couple of years, some changes have occurred in the IFDM system. One change was the increase in total farm acreage when an additional 160 acres of land was purchased and added to the salt-sensitive production area of the IFDM system. Additionally, the salt-sensitive production area increased from the conversion of some land originally used to grow salt-tolerant crops. There was a shift from surface irrigation to drip irrigation that resulted in higher irrigation efficiency and lower drainage water yields, and, consequently, the area of salt-sensitive crops was increased in acreage and the salt-tolerant crop area could be reduced. This highlights the need for a detailed evaluation of existing and proposed irrigation practices as part of the design process.

The revised and present cropping system now includes:

Salt-sensitive crops	1,022 acres	85.6 %
Salt-tolerant crops	132	11.1
Halophytes	40	3.4
Total	1,094	100.0

The IFDM system was designed to operate with the following management strategies: either reuse drainage water twice (to salt-tolerant crops and then halophytes) or only once (to halophytes). Lettuce, asparagus, bell peppers, melons, carrots, garlic and onions are grown in the area of salt-sensitive crops. Cotton is grown in the area of salt-tolerant crops. Native saltgrass, NYPA saltgrass and iodine bush are grown in the halophyte section. Sprinklers (the same sprinklers and spacing as described in the solar evaporator design specifics, except for 24-inch riser height) are used to distribute drainage water in the halophytes to prevent water ponding and to increase salt leaching.

4) Physical Description of the AndrewsAg Inc. Solar Evaporator

The solar evaporator consists of a 20-acre spray field (photograph no. 1) supplied by a close coupled turbine pump mounted on a concrete sump (photograph no. 2). The site has been graded to meet the regulations as required to control potential rainfall developed runoff. As can be noted from photograph no. 1, the site is relatively flat and devoid of vegetation.

The spray field is irrigated by a buried solid-set sprinkler system. Specifics of the design are as follows:

Sprinkler: Rainbird model SLL2OVH, 1/2-inch
Steel impact sprinkler with 7/64-inch nozzle

Sprinkler Performance: 2.32 gpm at 45 psi
Wetted radius, 28 feet

Spacing: 30 feet by 45 feet (triangular)
Estimated uniformity coefficient 85%
Application rate, 0.17 in/hr. (gross)

Riser: 1/2- inch schedule 80 PVC pipe by 12 inches long

Lateral Pipe: 2-inch schedule 40 PVC pipe with solvent welded joints

Mainline Pipe: 6-inch schedule 40 PVC pipe with solvent welded joints and fittings

Valves: Manual valves were installed to allow for the individual operation of the 8.0 and 12.0 acre blocks

Pumping Plant: Capacity, 900 gpm at approximately 140 ft. TDH

Operation: The sump collects the drain tile discharge from the halophytes. As the sump fills up, a float switch actuates the pump thereby sending the drainage flow to one of the spray field blocks. The operation is managed visually such that before surface free water is observed, the valves are adjusted manually, sending the pump discharge to the second spray field block.

Tile drainage water from the halophytes is collected in the holding basin shown in photograph no. 3. The pump shown transfers this water to the concrete sump shown in photograph no. 2. This provides some needed surge capacity, thereby allowing for efficient operation of the system. The sprinklers are mounted on short risers to ensure that the salt spray does not leave the site. The sprayed water quality is a natural herbicide, as no vegetative growth can be observed on site. The spray field is located in the bottom of former evaporation ponds. Lumps of salt that were transferred from the former evaporation ponds are visible in photograph no. 1.

Photograph 1: View of the spray field featuring a buried solid-set design

Photograph 2: Spray field pumping plant showing a close-coupled turbine pumping plant mounted on a concrete pipe sump. Note spare pump.

Photograph 3: Holding basin collecting the drainage discharge from the halophyte area and the booster pump that transfers the water to the spray field pumping plant.

This IFDM system is operating with satisfactory results and is being used as a model design framework for new IFDM systems. The original objectives have been achieved by (1) improving irrigation efficiency and management, (2) sequentially reusing drainage water on salt-tolerant crops and halophytes, and (3) discharging the final volume of drainage water into a solar evaporator.

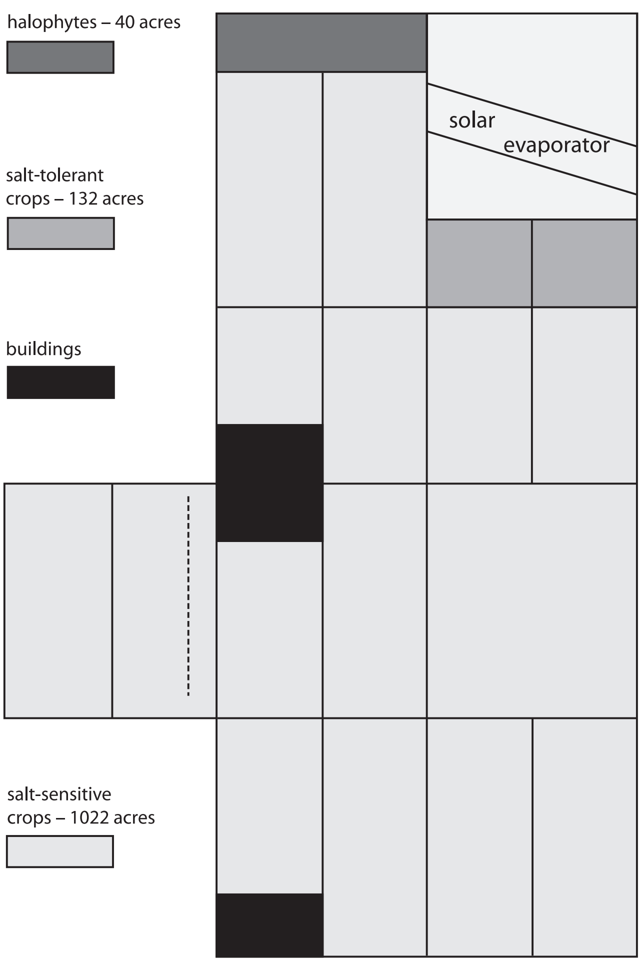

Figure 2-1. Schematic layout of AndrewsAg IFDM System.